

# Impact of climate change in Mexican peri-urban areas with risk of drought

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## ABSTRACT

This study analyses impacts of climate change on peri-urban communities that are at risk of drought and further demonstrates that these communities are aware of this change. This study is focused on two Mexican cities, Aguascalientes and Hermosillo and their respective peri-urban communities, to demonstrate the shared awareness of increased temperatures as well as rainfall decrease. Vulnerability experienced by both communities differs by dimensions like exposure and sensibility to the climate variability. Participants from the Hermosillo community report experiencing acute changes in their environment indicating a higher exposure to climate change. The community near Aguascalientes reported moderate changes in temperature extremes and changes to precipitation levels. A valuable tool in finding adaptation strategies to deal with climate change will most likely be the use of local knowledge and traditional practices from the studied areas.

## 1. Introduction

Climate change effects are already perceptible in diverse places and with different intensities all over the world (Ebi and Semenza, 2008; IPCC, 2014; Chaudhary and Bawa, 2011; Taylor et al., 2017). In order to design strategies for adaptation to climate change there is an urgent need to examine the social vulnerability to climate change from a contextual perspective, assessed in terms of the characteristics of specific social and environmental systems. Here we focus on peri-urban areas, defined as spaces located in the urban peripheries that serve as an interface between urban and rural territories. These areas share characteristics of urban and rural spaces, whether in contiguous or fragmented units. Households in these sites might still develop traditional activities, sometimes in the primary sector, but pursue a wider range of employment activities in nearby city given their proximity, though often with low paid jobs (Morton et al., 2014).

In this paper we analyse the vulnerability of communities in semi-arid areas, considering that an important number of studies of adaptation to climate change have developed in arid and semi-arid environment in Africa, Australia, North America and with some cases in Mexico (Midgley et al., 2012; Vázquez-León et al., 2003; Altieri and Toledo, 2005; Wheeler et al., 2013; Eakin et al., 2012). For example, in the case of droughts in Australia, adaptive strategies have been increased to improve harvests, from the sale and purchase of land, to new forms of irrigation and mix crops. Farmers acknowledge climate change and studies have shown that there is a relationship between their

perception and adaptation to risk (Wheeler et al., 2013). In the case study of Vázquez-León et al. (2003), they show how economic and social dissimilarities in close locations at the Mexico-United States border region have a strong influence for adaptation. This study analyses two communities that live side-by-side, one in Arizona and the second in Sonora, but the big difference in this semi-arid zone is how local capacities and ethnicity are factors that impact the degree of vulnerability.

Altieri and Toledo describe good practices in the agriculture sector based on local knowledge in semi-arid and extremely poor regions. It is thanks to the knowledge inherited from generation to generation that agro-biodiversity and agro-ecosystems subsist in different places and societies under climate variability context. These experiences are interesting because provide examples of adaptation strategies to climate variability, including actions such as collection of rainwater and the cultivation of mixed crops that have supported food subsistence in these communities. Moreover, several authors, including Berkes et al. (2000), Heyd (2010) and Vander Molen (2011) state that perceptions attribute qualitative characteristics to environmental assets through references that are elaborated from specific cultural and ideological systems, constructed and reconstructed by the social group, which allows to generate evidence about conservation practices in their territory.

Climate change impacts depend on the nature, magnitude and speed of the change to which a system is exposed, as well as on its sensitivity and adaptability (IPCC, 2007; UNDP, 2008). Vulnerability is the degree to which people are affected by factors that disrupt their lives and are

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beyond their immediate control, for instance increase in temperature and/or reduction in precipitations might have a major impact on the primary sector in peri-urban areas. Under these changes, communities might be impacted by losses of food production, but also by reduction in water supply, morbidity and mortality derived from food, water and vector borne diseases, and several other consequences on human well-being (IPCC, 2012). In particular, there is warning that local changes in temperature and rainfall have altered the distribution of some vector borne diseases. The IPCC (2012) indicates that all “these impacts are consistent with a significant lack of preparedness for current climate variability in some sectors” (p. 20). This means that climate change in peri-urban socio-ecological systems is explained by the magnitude of the risks, as well as the capacity of the society to manage them and implement coping tactics and adaptation strategies. Climate change risks are amplified for those communities which do not have access to basic infrastructure and who live in areas with high exposure. Exposure refers to the degree or intensity of an event, for instance heat waves, hot temperatures, reduction in rainfall patterns, drought events or vector spreads. Sensitivity relates to the harmful socioeconomic impacts of climate variability, for instance production systems that depend on temperature and rainfall, or infrastructure affected by weather conditions. Finally, the adaptive capacity denotes to the response to deal and recover from the impacts of severe climatic events, this capacity is explained by socioeconomic conditions at the household level, but might be reduced by the lack of health facilities, absence of communication and social networks or deficiency in institutional programs (CONANP-GIZ, 2014).

In semi-arid, peri-urban areas, adaptive capacity might take advantage of ecosystem based approaches to reduce the impact of increased temperature and reduced rainfall, together with engineered and technological options to improve water management and diversify economic activities (IPCC, 2012). In fact, there is a need to better understand the trade-offs between natural ecosystems in semi-arid regions, with poverty and vulnerability to climate change in order to sustainably manage these socio-ecological peri-urban systems. An important issue to achieve adaptation policies guided by the sustainability paradigm is the effective use of environmental goods and services, where water resources are often scarce. It is argued that natural systems can be used to reduce the effects of heat waves, provide food and water, and so on (McPhearson et al., 2015). Particularly in peri-urban areas there is a mix of urban infrastructure with natural systems that increases the availability of certain environmental services and can be used to improve community resilience. A resilient system copes with disturbance, responding in ways that maintains its essential function, identity, and structure, while also maintaining the capacity for adaptation (IPCC, 2012, p 5). Improving resilience in peri-urban communities would generate the capacity to deal with reduced rainfall or warmer temperatures in a way that do not affect negatively their intrinsic identity and wellbeing. However, it is necessary to develop planned systems that effectively use environmental assets in favour of reducing the potential risks of climate hazards. Moreover, available natural resources might provide direct services to the poor in some peri-urban communities, which are free or low cost, such as water and food, thus conserving, improving and using the available natural assets should be a priority to reduce vulnerability (TEEB, 2010).

The assessment of vulnerability at the local level permits greater understanding of the impacts of climate change in specific contexts. At the local level, there is recognition that the planning and implementation of adaptation strategies are intimately linked with culture, social values, risk perception and local characteristics. To improve decision-making, socio-cultural contexts and community expectations must be recognized. Local cultures would deal differently with climate change impacts in concrete and abstract ways, for instance how people perceive and react to impacts on wellbeing associated to heat increase or abstract impacts to identity values of a community when there are changes in traditional economic activities originated by weather

changes (Swim et al., 2009). Therefore, local and traditional knowledge systems and practices are important sources for information to define improved adaptation strategies (IPCC, 2007). We see community involvement towards self-management and adaptation as the key to reduce vulnerability to climate change, with gender equality gaining importance. This analysis requires a bottom-up approach, which according to Van Aalst et al. (2008) has the advantage of using actual observation of current climate impacts and how communities respond, thus results reflect experiences of people living in a specific area instead of assumptions based on aggregated information. In this research, the concept of “community-based adaptation” is central, which can be defined as “a guided process by communities based on their priorities, needs, knowledge and ability to empower people to plan and cope with the impacts of climate change” (SEMARNAT, 2012: 34).

This paper further seeks to expand current understanding of vulnerability by contextualizing how climate change impacts socio-ecological systems in peri-urban areas in Mexico, where public service infrastructure is often scarcer and where there is a predominance of households living in poverty (Galindo and Delgado, 2006, González and Larralde, 2013). According to official information, Mexico is highly vulnerable to climate change. The authorities have stated that climate change represents a risk to national security because it threatens to impede the country's economic and social development. Climate change scenarios project that by 2050, the country's arable areas could be reduced by 25%, half of the forest ecosystems would change to drier climate vegetation, with the consequent impact on biodiversity; while droughts could affect 80% of the population in the north and centre of the country, where the greatest economic activity of the country is concentrated (SEMARNAT, 2014; Herrera-Patoja and Hiscock, 2015). In general, the projections of the global scenarios indicate that by the end of the 21st century there could be an increase in temperature of about 4 °C in the north of the country and between 2.5 °C and 3.5 °C in the rest of the territory. The projections also indicate reductions in precipitation between 5 and 10%. In particular, drought risk is a priority issue in Mexico because most of its territory is composed of dry and very dry climate regions. National data show that roughly 40% of the population is located in areas at risk of drought occupying more than 60% of the territory from the centre towards the northern regions (CENAPRED, 2014).

In the climate policy making, the National Institute of Ecology and Climate Change (INECC) has responsibility for defining and implementing policies and programs related to the mitigation and adaptation to climate. Mexico is a leading country among emerging economies, with a series of legal and institutional arrangements to coordinate climate change policies at different sectors and between different level of government (SEMARNAT, 2012 & 2014). One milestone was the publication of the General Law on Climate Change (LGCC) published in 2012, which places the country as one of the first, together with the United Kingdom, to have national legislation on the subject. Despite this LGCC and the other institutional arrangements, such as the Inter-Ministerial Commission of Climate Change created in 2005, there are critics about how this legal and institutional framework has hardly had impact on local grounds. At the state level, there are efforts to develop State Programmes of Climate Change with inter-ministerial structures of governance, but their progress and effectiveness changes and it is usually explained by budgets size (Valdez et al., 2006). An interesting program for urban areas is a program of the Trust Fund for Electricity Savings (FIDE), a mix of private and government institution that promotes and funds projects for efficient electricity end-use. It operates the Support Program for Distributed Generation that facilitates credits for the acquisition of photovoltaic systems in the domestic sector and in small and medium business (IEA, 2016).

Peri-urban areas being still rich in natural resources, thus it is worth saying that Mexico is one of the most biologically diverse countries. The country is home to 10–12% of the world's biodiversity. Yet official data report that 1165 species are threatened. A great proportion of

biodiversity is located in Ejidos, a form of land property that is communally owned. Ejidos occupy about 50% of Mexico's land (INEGI, 2016b). Mexico has a number of policy instruments to promote the conservation and sustainable use of biodiversity and forests, such as payment for ecosystem services, reforestation programs, controls on illegal hunting of wildlife and a system of wildlife management units that allows use of wildlife under conservation management (OECD, 2013; Kernan et al., 2013). These instruments have delivered mixed results, but their design needs review with the aim of targeting the needs of different locations (OECD, 2013).

In this research two peri-urban communities in Mexico located in drought risk areas were selected. Information obtained from workshops in two selected communities of Aguascalientes and Hermosillo cities served to identify perceptions regarding the changes in climate conditions. Semi-arid conditions, variable precipitation and diverse levels of droughts characterize these two cities. Both cities experience population growth and water resources in both states are scarce and a major cause for concern. The first focus of this research was to learn if some climate change effects were already perceptible in the selected communities, and to understand how people perceive changes and whether they had adopted any strategies to reduce vulnerability. The paper has four sections, after this introduction, the second section describe the methods, including typify of peri-urban areas of Mexico and identify the climatic related vulnerability; description of the selected study cases, and the method used to undertake the workshops regarding four dimensions of vulnerability. The third section presents the results divided into the four dimensions of vulnerability and tables with a summary of impacts observed in both communities. Finally, the discussion and conclusions section integrates the consideration of both cases, and provide recommendations oriented to consider possible adaptation deliberations in these drought-prone peri-urban communities.

## 2. Materials and methods

### 2.1. Definition and characteristics of peri-urban areas

The specialized literature shows two main routes to study the peri-urban areas: the first is from urban studies in which it is generally treated as a result of the urbanization process (Ávila, 2001). The second is from regional or rural studies and addresses the analysis of peri-urban areas from urban settlements and their relationship of interdependence with urban centres (Arias, 2005). For the purposes of this study we have adopted the definition of peri-urban zones as those spaces located in the urban peripheries and that serve as interface between the urban and the rural. Spaces that present spatial contiguity, and which are areas with urban and rural attributes, such as built, cultivated and/or natural spaces. These zones often combine modern and traditional ways of life, and these hybrid spaces produce particular social interactions of individuals, groups and/or institutions, granting the peri-urban area its own characteristics. In operative terms the peri-urban spaces are those that are distinguished from the urban and the rural ones by having a greater heterogeneity of land uses, considering that urban spaces are predominantly built up; rural areas are predominantly not built (cultivated or natural); and peri-urban spaces are mixed uses of land, both built and cultivated or natural.

In our investigation, peri-urban areas were defined using Land Use Charts (1: 50,000), Population and House Census (INEGI, 2010), data about economic units (DENUE, INEGI, 2017) and the National Road Network (INEGI) (reported in Alfie, 2017). The risks associated with climate change in urban areas were established by analysing the relationship between indicators of climate vulnerability used by the National Centre for Disaster Prevention (CENAPRED), together with social, economic and environmental variables. Other information such as number of deaths caused by climate events and Emergency and Disaster Declarations were also considered (Alfie, 2017). This information enabled classification of the urban and peri-urban areas within three main

climatic risks: cyclones, droughts and flooding. Some urban areas presented two or three of these risks, but given their geographic location these were classified into one predominant climatic risk category. In the drought predominant category, inland cities instead of coastal cities were chosen.

Once the classification was developed, study cases were defined for deeper analysis. In these cases, people's perceptions on climate change in specific peri-urban areas with drought risk characteristics were analysed. Our selection considered cities with diverse location and weather conditions, and also the potential local partners. A local partner was central because they would inform the research team about specific communities in the peri-urban area that could be of interest due to their climatic vulnerability or socio-economic conditions, which justified the study. The selected cities were City of Aguascalientes located in the central area of Mexico and City of Hermosillo located in the northern area of Mexico. The National Centre for Disaster Prevention used historic records, considering data from 1948 to 1996, aimed to classify the risk of droughts, the two selected cities, Hermosillo and Aguascalientes cities, are classified as medium drought severity degree (CENAPRED, 2014).

Hermosillo City is located in the centre of the state of Sonora, 280 km from the border with the United States, with a population of 884, 273 inhabitants (INEGI Gobierno de Sonora, 2015). The 168.2 km<sup>2</sup> area, is characterized by a mostly limestone arid terrain, at an altitude of 210 m above sea level. The Köppen climate classification of Hermosillo is desert, for the period 1981 to 2010, it had an average annual temperature of 25 °C, with an average maximum of 49.5 °C and an average minimum of −4 °C. During most of the year the temperatures are between 31 and 39 °C. It rains mainly during July and September, with an average annual precipitation of 376 mm.

The State of Sonora does not have a Climate Change Law as in other states, but it has a State Action Plan on Climate Change, including the preparation of the GHG inventory, the identification of 46 priority policies and the creation of an Advisory Group and five Technical Groups of Work in charge of the follow up actions. However, the State Action Plan includes only mitigation policy actions, the adaptation policies are still pending (GES, 2018).

The City of Aguascalientes is located in the centre-south of the state of Aguascalientes, the city covers an area of 1168.72 km<sup>2</sup>. It is part of the region of Bajío, and lies at an altitude of 1888 m above sea level. It has about 1 million inhabitants, registering higher average rates in human development. The average annual temperature is 18.5 °C, the highest average temperature is 26.4 °C and the minimum −7 °C. The weather in the city is semi-dry and semi-dry tempered. The average annual rainfall is 518 mm, and the rainy season is in summer, starting at the end of June and ending at the end of September (INEGI, Gobierno de Aguascalientes, 2015). The state has enacted the Law of Climate Change of Aguascalientes State published in 2015, but it does not have a State Action Plan on Climate Change yet.

In the first months of 2017, the research team began formally working with local partners. When contact was established and our partners agreed to collaborate, they proposed specific areas to work and the research team analysed the general profile of each one. In Aguascalientes, the Centre for Research and Teaching in Economics (CIDE), campus Aguascalientes, defined the area supported by a local environmental NGO, Environmental Movement (Movimiento Ambientalista A.C). In Hermosillo, the Environmental Attorney of the State of Sonora defined the case based on their records on problems associated with vulnerability to drought events in the region. The selected study cases were Los Pargos in Aguascalientes City and San Pedro-El Saucito in Hermosillo City (see Fig. 1).

### 2.2. Periurban communities' characteristics

#### 2.2.1. Los Pargos, aguascalientes

Los Pargos is a small Ejido (a legal form of communal land) near



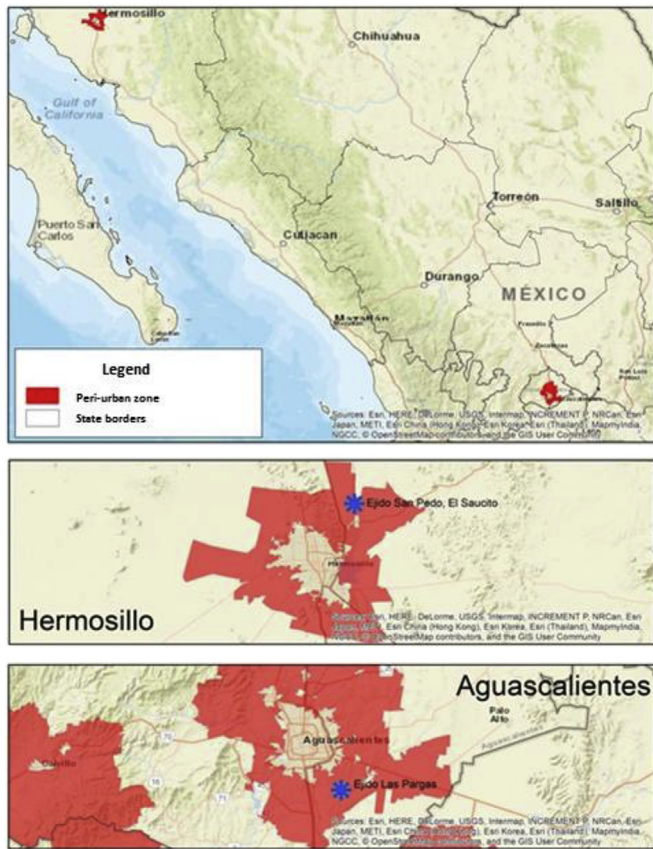


Fig. 1. Selected peri-urban areas in Mexico: Hermosillo and Aguascalientes. Source: Laboratory of Socio-territorial Analysis- LAST (2016)

Aguascalientes City. This peri-urban community is characterized by it is naturally rich environment, formed by a mezquite forest and with a medium-size dam (See Fig. 2); it is an important habitat for birds and other small species. Local organizations highlight the importance of Los Pargos due to the ecological richness and the presence of paleontological artefacts that have been found in here. Due to the dam and forest landscape this area receives tourists from Aguascalientes City, mostly during weekends and over Easter. However, there is no infrastructure or services offered for tourists, like restaurants or shops, and the community, do not receive any benefit from this tourism.

According to official data, Los Pargos has 235 inhabitants, with 53 inhabited households in total (INEGI, 2010). All households have electricity, 43 households have piped water, and the rest are served by public water tanks, only 27 households have sewage connection. In the community streets are not paved, there is one preschool and one primary school. Official data indicates that the average number of education in the community is 5.7 years. The closest health services are in the urban area, but 49 people do not have access to public health services (INEGI, 2010).

Los Pargos Ejido does not have polygonal data officially defined, but geographic information obtained of soil and vegetation use layer (INEGI, 2016a), allow to observe that considering an area with a buffer of 50° m, there are four main categories of land use, 35.47 ha of secondary vegetation composed mainly of shrubs (including mesquite), 2.34 ha of human settlement, 283 ha of non-irrigated agriculture, and about 15.3 ha are occupied by the Los Pargos dam.

There is not official information about economic units, the only available information is the census data. However, it is well known that brick fabrication is the most important economic activity; many of the families in the community have their own production unit based on traditional techniques. The environmental authorities regulate the materials used in order to avoid the use of fuel wood or other highly polluting materials for brick manufacturing purposes.

#### 2.2.2. San Pedro-el Saucito, Hermosillo

San Pedro-el Saucito is an Ejido near Hermosillo city, this is a larger

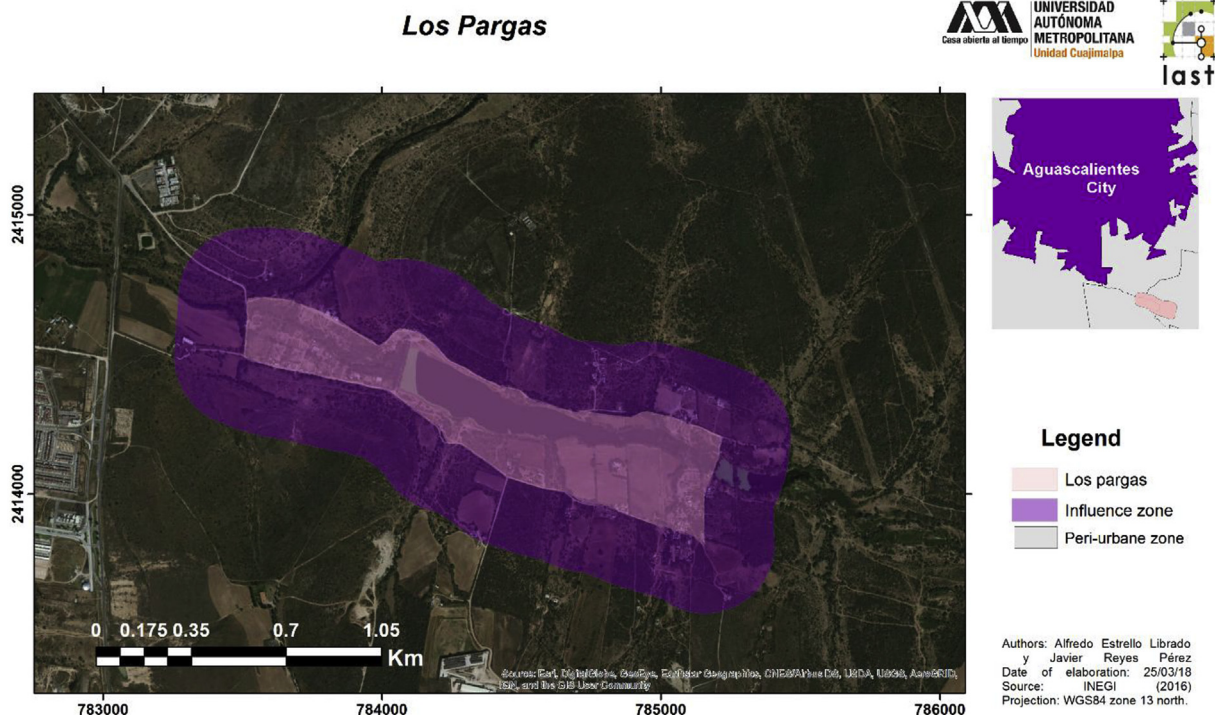
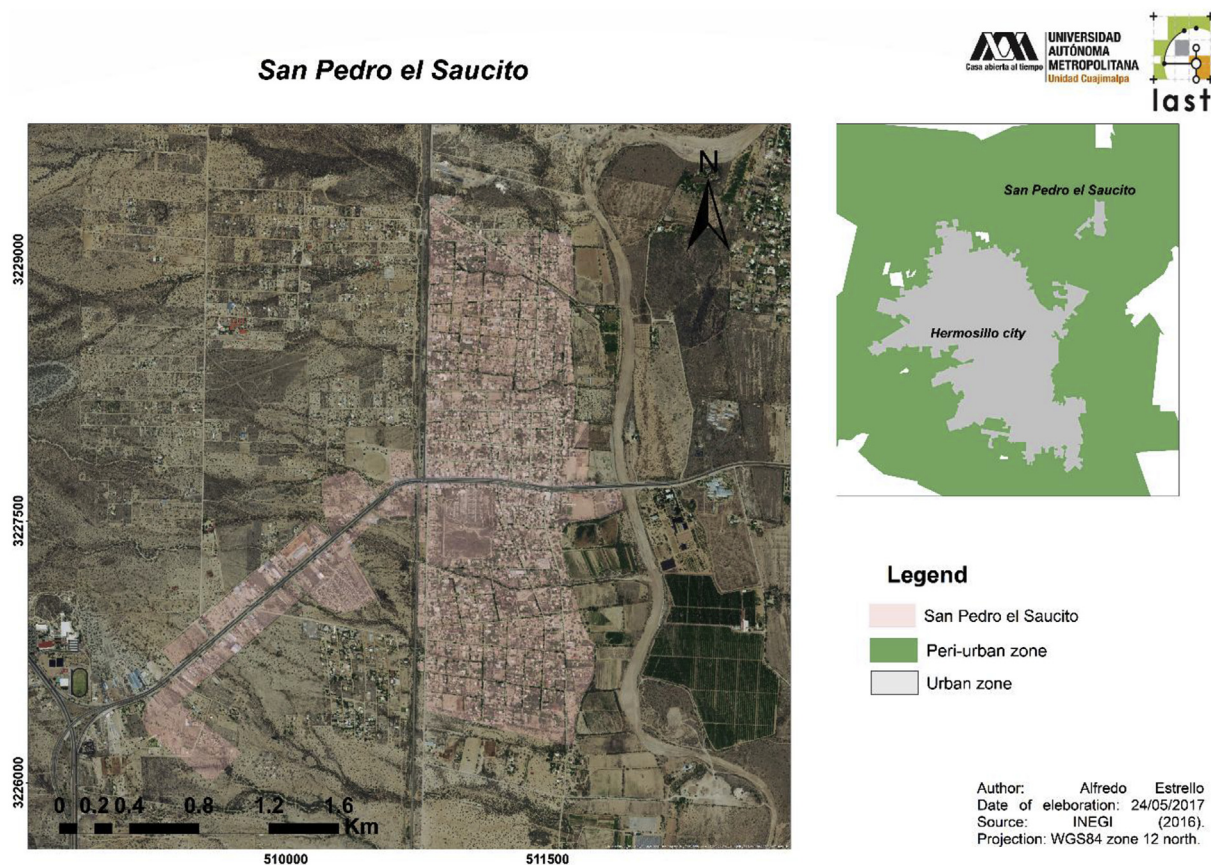


Fig. 2. Location of Los Pargos: peri-urban area of Aguascalientes. Source: Laboratory of socio-territory analysis (2016)



**Fig. 3.** Location of San Pedro el Saucito: peri-urban area of Hermosillo.  
 Source: Laboratory of Socio-territory Analysis-LAST (2016)

peri-urban community, with houses, restaurants and some tourism facilities and roads (see Fig. 3). According to the 2010 Census 2938 inhabitants lived in this Ejido, with 725 inhabited households in total (INEGI, 2010). 95.86% of the households have electricity, 91.17% have piped water, 87.03% have sanitation services, but the streets are not paved. The weather in Hermosillo is dry-warm and the annual precipitation average is between 186 and 197 mm. Official data indicate that the total surface area of San Pedro el Saucito Ejido is 349 ha, of which 100 ha are vegetation (mezquite), 247 are urban and only 2 ha are agricultural land. The economic census indicates that there are 189 economic units, 22% are restaurants and food preparation establishments. About 34% are diverse commercial establishments and interestingly there are only one service associated to agriculture, but none of livestock or horse activities registered (INEGI, 2014). This might be because these activities can be undertaken without formal registration.

Due to their proximity to the city some residents of Hermosillo City have holiday homes in the area. Communal or Ejido landowners organize in the assembly, which is the principal decision-making body within any given Ejido. Agriculture and livestock were the most important activities in the area, though now small commerce activities have increased. In the past people did not use low-impact irrigation practices, but due to water scarcity problems the current producers use more drip irrigation systems.

Information about the peri-urban communities is summarised in Table 1.

### 2.3. Description of the workshops

The methodology proposed by the National Commission of Protected Areas, developed together with the Deutsche Gesellschaft für Internationale Zusammenarbeit (CONANP-GIZ, 2014) was used to

analyse the study cases. The methodology proposes to analyse four dimensions of vulnerability through workshops (DiV) (See Table 2). The first dimension is life strategies and wellbeing and includes issues related to how weather conditions impact people's daily life strategies, by understanding the social, economic and ecological characteristics of the community. Here, questions are designed to assess participants' perceptions of changes in weather conditions and the impacts in their daily life strategies. This includes a description (from January to December) of the weather conditions to understand and illustrate changes in their seasonality. The second dimension is adaptive capacity within the household and in their economic activities. This stage includes a mapping exercise to describe the location of community infrastructure, including water sources, schools, clinics, shops, among others. Natural assets and risk areas, such as forest, superficial watersheds, flooding and landslides areas are identified, including households that live in specific risk areas or marginalized sites. The third dimension is adaptive capacity of the community, by learning about the norms, practices and institutions within the community. The fourth dimension is governance, the existence and functioning of official institutions and programmes that might influence the community's ability to deal with decision making and collective problems.

We selected this methodology because it allows us to evaluate vulnerability of climate change including three important aspects considered in our research project (CONANP-GIZ, 2014, p. 12): to get local information on climate impacts, understand the social causes of vulnerability, and increase the effectiveness and efficiency of local adaptation proposals. However, we reduced the original version guideline because it was more oriented to rural contexts, with long workshop and interview activities, which is not feasible in peri-urban contexts because inhabitants were unwilling to participate in long working sessions due to their regular jobs and household duties.



**Table 1**

Description of the two selected peri-urban areas.

Source: Own elaboration with data collected from CONAPO and INEGI

Selected area– municipality	City – State	Weather type and risk of drought	Population	Local partner
Los Pargos	Aguascalientes, Aguascalientes	Temperate. Precipitation 211 mm	235 inhabitants, 53 households	■ Centre for Research and Teaching in Economics (CIDE)- Aguascalientes.
San Pedro el Saucito	Hermosillo, Sonora	Dry-warm Precipitation 186–197 mm.	2938 inhabitants 725 households	■ Environmental Attorney, Government of Sonora.

**Table 2**

Dimensions of vulnerability.

Investigated categories.
DIV 1: Life Strategies and wellbeing
● Social and ecological characteristics of the community.
● Important climate impacts for the community (Description from January to December) of the weather impacts to understand their seasonality).
● Impacts on life strategies due to climatic trends.
DIV 2: Adaptive capacity of people and households
● Access to resources to adapt, according to social groups in the community.
● Mapping of infrastructure, services, natural assets and risk areas.
DIV 3: Adaptive capacity of the community
● Community norms, practices and institutions that influence vulnerability and collective adaptive capacity.
DIV 4. Governance
● Capacities and responsibilities of political actors and organizations linked to processes of vulnerability and adaptive capacity.

Source: Adapted from CONANP and GIZ, 2014.

These four dimensions consider different aspects of vulnerability: exposure, sensitivity and adaptive capacity. Available documents related to the demographic and socioeconomic information in Los Pargos and San Pedro el Saucito communities were used to prepare and refine the analysis and the workshop guide.

### 2.3.1. Data collection and analysis

A series of scoping visits and workshops were used to document the impact of changed conditions and assess population perceptions of possible impacts of climate change. Each community was visited twice, first for a scouting session and later for the workshop. The scouting visits had the objective of meeting with the local partner and visiting the community, we aimed to talk with local leaders or stakeholders in order to define the conditions for the workshop, including invitation of participants, workshop location and other logistic arrangements. The visit permitted informal conversations with the local leaders to talk about the characteristics of the community, and to learn more about the economic activities and possible impacts of weather changes. These scouting visits were conducted in April 2017. The visit was essential to present the project objectives to the community leaders and welcome their comments. These contacts helped working in a safer, trustful and productive environment with the local partners and the leaders of the communities.

Two workshops were conducted in each community using the protocol guide based on the above explained vulnerability dimensions. The protocol guide oriented the conversation but allowed for flexibility in its composition. The strength of this approach largely relies on the researcher's ability to adapt the conversation process to ensure that each participant provides information about the same topics.

We tried to have workshops with inhabitants with varying profiles, for instance women and men, people of different ages, people with different employments. However, in Los Pargos (Aguascalientes) the two groups were composed by women, because the local leader (*comisaria ejidal*) who is a woman was not able to convince men to attend; despite this the groups included women with variety in ages, occupations and household location. In San Pedro el Saucito (Hermosillo), one

group of participants was composed of women and the other by men. The women were diverse in terms of ages and occupations, but men were mostly landowners.

Table 3 presents socio-demographic data of the workshops participants. A total of 26 women participated in the two workshops in Aguascalientes. These women were between 19 and 70 years old (media of 48 years old), most of participants have low education level, with two illiterate, 4 with primary school and 14 with secondary school. In terms of job activity more women were housewives, but there were 5 women working in brick production, three women worked in retail commerce and only one worked outside of the community. In San Pedro el Saucito, there were 9 women in one workshop and 5 men in the other. The women were between 24 and 70 years old (median of 46 years old), while the men were between 49 and 70 years old (median of 55.5 years old). The education level in the women group was diverse, 3 completed primary school, 3 reached secondary school, 1 graduated high school, while 2 received a graduate degree. The men participants have low education level, with 1 being illiterate, 2 with primary school skills and 2 completing secondary school. In terms of job activity 6 women were housewives and 3 women worked in local restaurants; while 3 men were landowners, one of them being horse groom, and 2 worked in agriculture.

During the workshop, participants were asked to draw a map of the community, indicating the location of the houses, infrastructure, schools or other public buildings, as well as the existence of water wells, the natural resources they considered relevant such as crops and, where appropriate, areas of particular risk. The drawing of the maps was prepared by a subgroup of workshop participants (4–5 people) who, later showed it to rest of the group to agree or, if necessary, add other elements. The workshops were 3–4 h long. During the workshop permission to audio record was requested, in the case of Aguascalientes it was also video recorded and notes were taken by the researcher.

For the analysis major themes in responses to workshop categories were identified and information on these topics was manually coded into the four vulnerability categories (Braun and Clarke, 2012). To undertake the analysis, full transcription of the tapes was undertaken and accompanying notes were also considered. When possible the name of the participant was written down at the end of each piece of intervention, given that it was audio-recorded. The information was divided in general themes following again the protocol guide (Braun and Clarke, 2012). The process of coding involved going through the text line by line and dividing the text into the particular themes (Tesch, 1990; Krueger and Casey, 2015). We used the copy and paste facility in Microsoft Word to separate each theme category. One piece of text may have been initially classified in more than one theme. Most of the text was assigned a theme, in order to avoid losing parts of the information as well as to be able to observe the regularities and different ways of expressing the same theme.

The coding frame started with broad codes from the protocol guide. However, as coding proceeded, these codes were broken down into sub-categories that related to the overall theme and which were demonstrated to be significant for the respondents. We observed that certain themes or sub-categories were more relevant than others, and that some of them were redundant. Conversely, some themes emerged from the data, which were not originally considered in the protocol guide. Thus,

**Table 3**  
Socio-demographic data of workshop participants.

	Number of participants		Age of participants	Education level		Job or main activity
	26 women	9 women		2 illiterate, 4 primary school, 14 secondary school and 1 high school.	13 housewives, 5 brick makers, 3 retail commerce, in cleaning work in the City.	
Los Pargos	26 women	9 women	Between 19 and 70 years old, average 48.	3 primary school, 3 secondary school, 1 high school, 2 graduate degree.	6 housewives, 3 retain commerce in local restaurants.	
San Pedro	5 men		between 24 and 70 years old, average 46. between 49 and 70 years old (media 55.5)	1 illiterate, 2 primary school, 2 secondary school.	3 landowners (1 horse carter), 2 agriculture.	

new categories were defined within specific themes, such as refinement of impacts of urban influence or people's expectations.

The four dimensions of vulnerability used to undertake the workshops (life strategies, adaptive capacity of people and households, adaptive capacity of the community and governance) were developed, but we found that participants gave rich and important information in regards to climate change impacts, such as changes in temperature, increase in vectors, changes in precipitation, and how these impacts affected households' wellbeing, economic activities and other aspects such as infrastructure. The thematic analysis approach gave flexibility and helped to fulfil the research objective. In order to explain the results, some relevant quotations are written to exemplify the treated theme.

The analysis of maps was based on the theory of social representations that takes the environmental psychology to consider the collective representations, as schemes of thought that guide actions in a specific socio-cultural context. (De Alba, M. 2012). They are seen as abstract representations that highlighting aspects of identity, structure of the composition and meaning of the space.

### 3. Results

#### 3.1. Life strategies and wellbeing

Peoples' perceptions in the peri-urban communities of Los Pargos (in the City of Aguascalientes) and San Pedro (in the City of Hermosillo) indicate how individuals are exposed to climate change impacts and how this affects their wellbeing. There is a shared awareness of changes in weather, with more heat and less rainfall in recent years. However, the vulnerability experienced by the communities differs drastically and is conditioned by the dimensions of exposure and sensitivity to the weather fluctuations.

##### 3.1.1. Perceived climate impacts

Participants in San Pedro perceive and gave data about acute changes in increasing temperature, reduced rainfall and scarce water availability, denoting a higher exposure. In San Pedro, the community manifested a climatic variability, such as the absence of "equipatas" (morning and evening drizzles in December), more intense heat, less rain, more wind and increased drought. They emphasized the increased heat that is perceived throughout the year, in particular the winter season. Participants mentioned temperature increases in the last decade with data that indicate extreme cases of up to 55 °C in the shade. The government gives a subsidy for electricity during the warmer season to reduce the cost of air conditioning, but participants indicate that this subsidy should be extended because the heat has a longer duration: "now the subsidy for energy starts in May and finishes in October, but it should start in January because the heat begins before".

In relation to droughts participants in San Pedro are convinced that the period of rain has been reduced and rain begins to appear when it was not due to, or it rains intensely on a few occasions. Emphasis is placed on difficulty in climate prediction. Older participants mention that years ago the weather was cooler with more rainfall. They perceive that the lack of rain is associated with the wells drying up. Less rainfall and scarce water availability has multiple impacts in ecosystems and economic activities.

In Los Pargos participants also demonstrated recognition on weather change in terms of variability in rainfall and heat patterns. However, participants here perceived that there is more extreme weather. The cold season, comprising from December to February, is more intense. Also during the morning-time it might be colder, but later the heat is more extreme. Here there is also, as in San Pedro, a general agreement that rainfall has decreased, they noticed it from the water level of the dam and they also manifested the absence of "cabañuelas" (morning drizzles in January and February). Another impact that they showed concern about is the presence of dust because there are stronger

winds now. However, in this community did not mention extremes in hot temperatures. In both workshops there were clear manifestations of the changes:

“The land has hardened, there is no longer moisture. Before that there was water at 4 or 6 inches of depth” (men, San Pedro).

“The weather has changed a lot, before it was hot, now there is fire, the heat is stronger” (woman, San Pedro).

“The rain is very scarce, before it lasted weeks raining, the walls were filled with mold, now it only rains one or two days ...” (man, San Pedro).

“If you see the time has changed. Sometimes it rains and in others months not a drop” (woman, Los Pargos)

In January and February there were *cabañuelas* that are drizzles. There are no *cabañuelas* anymore. Now there is only cold (woman, Los Parga).

### 3.1.2. Impacts on life strategies due to climatic trends

People in San Pedro perceived declining economic activity associated with agriculture and livestock. In hotter, drier conditions, traditional activities in the Ejido have changed substantially and in some cases stopped. Participants mentioned that they used to cultivate corn, vegetables, as well as produce livestock. Many producers have stopped because the lack of water and climatic factors, i.e. dry wells. Less rain, more heat, more wind and more insect plagues have affected the local economy denoting a high sensitivity to weather changer.

In fact, during the workshop the instructor was asked not to mention the term “climate change”, but participants in San Pedro expressed how “climate change” has modified their lifestyles. A consequence of the heat is that the people went to the city to look for work because there are no “milpas” (mixed crops and traditional form of agriculture) anymore. The situation of vulnerability is higher for those who are still engaged in these activities, indicating that still about 100 people are engaged in agriculture. Agriculture is still happening, but with less quality due to warmer weather, water extracted from deeper depth with lower quality-more salt- and less rain.

In Los Pargos though participants recognized the effect of weather variability, they said that their main economic activity, the brick production benefited with fewer rainy days, because their work can be extended during more of the year. In Los Pargos participants believed that more variance in weather conditions influenced abandonment of agriculture but that this was years ago. However, families living close to the Pargos Dam have maintained agriculture activity because they use its water to irrigate crops. Despite the possibility of having access to irrigation from the dam, a participant mentioned that there is a greater presence of pests due to the heat conditions.

Regarding impacts on household wellbeing, although the main economic activity is not negatively impacted in Los Pargos, wild food resources provide direct provision services to the people living in the community. The collection of nopal (cactus), tuna fruit, the heart of the penca, and maguey as a source of food is an important benefit for the local families. Also rabbits, hares or field rats are hunted and supplement their diets. Medicinal plants were also mentioned as an important asset of the area and are also in decline. In this context, participants report that decreased rainfall has reduced their source of free food and lead them to buy these products in external markets. Fall in wild nopal and maguey is impacting the presence of wild animals for hunting, because nopal plant is a refuge for these small rodents, particularly field rats. This topic was a great concern, since we should remember that in this community only women attended the two workshops.

Several participants in Los Pargos mentioned having pigs, calves, rabbits or hens in their backyards. To protect animals from the heat and the rain, they install “tejavanas” (roofs). A concern is that in the hot season animals are developing diseases more often. According to their

perception, animal farming is severely affected by the climate, including the deterioration of pasture. Fishing in the Parga Dam is another activity that also provides food all year, but there are significant restrictions on the type of fishing gear they can use.

On the other hand, participants in San Pedro complain about the high temperatures. Recent extreme temperatures above 50 °C produce increasing discomfort, reduced possibility of being outdoors and negative health effects. They referred to irritability, “bad mood because of the heat”. In the “*malhora*” –bad hour-people are kept in their houses due to the heat. People use evaporative coolers, a system of “air conditioning”, that uses water, but when there are water shortages the coolers are not effective. In addition, fans are used, but both systems consume electricity that is expensive.

The health effects associated with the extreme heat produce dehydration in San Pedro and in both communities the presence of gastrointestinal diseases due to the risk of food spoilage and fly proliferation. Participants in both communities also perceive negative effects due to dust produced by the drier environment and unpaved streets. They complained about dust with expressions such as “We eat dust”. The impact on health has a higher incidence in children and elderly population, while families without access to health services are more vulnerable.

In Los Pargos participants mentioned that the immediate impact of “colder and more changing weather” is respiratory symptoms and diseases such as coughs, bronchitis and asthma. However, certain participants raised the issue of pollution produced by the brick kilns. Emissions from brick kilns is a well-known problem that produces suspended particulate matter that cause serious health hazards to the eyes, lungs and throat. Although people know that smoke is a health hazard, they argue that this is their most important source of income.

Some participants in San Pedro mentioned the increase in mosquitoes and vector borne diseases, particularly dengue and few cases of chikungunya. Women participants were concern by the increase of flies, mosquitoes and sometimes ticks. One of the main issues participants pointed it was street garbage and poor water storage. Both are the cause of vector borne diseases, but literature also indicate temperature and rainfall changes as a source of vector proliferation (IPCC, 2012). Participants referred to cases of dengue, which have increased abruptly. Nevertheless, participants stressed the effectiveness of “descacharre program” (discard program) promoted by the state government aimed to get rid of places where mosquitoes can reproduce. However, people still perceive mosquito presence and complain that some people used to sleep outside, but now there are mosquitoes.

In San Pedro and Los Pargos complained about garbage everywhere with harmful consequences to fauna and feral dogs. In the rainy season garbage enters streams and overflows when it rains hard. With the temporary employment program promoted by the government, women in both communities have been hired to clean their towns during certain times.

Here are some reflections of participants regarding impacts on life strategies and wellbeing:

“I see that now land has hardened because it does not rain, before there was a well of 10 m, now with wells of 30 or 40 m do not longer reach the water” (man, San Pedro)

“Ejidatarios got affected a lot by the weather change; some people sold their lands because before many people were dedicated to agriculture” (woman, San Pedro).

“Years ago young men were dedicated to the “milpa”, but when the water was gone the people had to go to the city, now the young people have to go to look for work (in the city)” (woman, San Pedro).

“If there is no rain there is not grass. The “agostadero” is the natural mount, where grass is born, buffer grass and natural grass. Even if there is not well water, but it rains there is food for cattle” (man, San



Pedro).

"When it rains you cannot work in the brickyard" (woman, Los Pargos).

"People no longer work in agriculture, there is no reason in spending on seeds, the land is forgotten" (woman, Los Pargos).

"We realize that there is less wild rat because there is less maguey" (woman, Los Pargos).

"What happens is that rats are kept in maguey and nopal, but now there are no nopales" (woman, Los Pargos).

"Mesquite wood is good for cooking beans, frying fish" (woman, Los Pargos).

"Because of the heat there are a lot of flies, people shelter in their houses, in Hermosillo the doors are covered with flies" (woman, San Pedro).

"People throw the bag of snacks or the water bottle to the street when they walk. Even a washing machine was outside a house" (woman, San Pedro).

"There are (street) dogs everywhere" (woman, San Pedro).

"Smoke from the brickworks is all year round. The smoke from the brick-layers spreads everywhere" (women, Los Pargos).

"The bad temper, because of the heat, I arrive to my home with a headache and bad mood (woman, San Pedro).

"The time of "malhora" is when people stay at home and do not go out" (woman, San Pedro)

"Asthma and dust allergy has exploded. There are more suspended particles. You have to pick up the children (from the school) by car because it is hot, but the cars raise the dust because roads are not paved" (woman, San Pedro).

### 3.2. Adaptive capacity of people and households

There is an effect of urban expansion on communities' adaptive capacity. In the case of San Pedro, the urban expansion of Hermosillo and the growth of roads and highways have allowed economic activities to diversify, but this also has negative impacts on scarce water resources. The negative effect of urbanization in San Pedro is the extraction of water from regional wells that used to supply the periphery communities. They mention that authorities have tried to bring water to Hermosillo from neighbouring areas and other states, such as Sinaloa and Cajeme, but the social resistance in those places prevented the execution of those projects. Some believed that pressure of urban extraction and large irrigation nearby was partly responsible for their water scarcity. According to them, water is diverting to supply large grape producers. They also mentioned how the mining industry pollutes water sources, for instance the well-known spill case of "Minera Buena Vista" that contaminated the Sonora River in August 2014.<sup>1</sup>

The need to diversify economic activities led to a number of families to initiate retail commerce activities. They explained that tourism as a result of being close to Hermosillo city could reduce their vulnerability to the agricultural decline and compensate their income losses. San Pedro has become a gastronomic corridor, where there is food for sale because they consider that the town is now a touristic place. Women participants indicated that San Pedro has the second most important gastronomic show in the state. Many women in the community have food preparation establishments, mainly small restaurants and street

food located next to the highway to serve transiting of urban residents using the highway.

Parallel, some men who used to produce livestock found an option in the horse care business in San Pedro. Participants indicated that there are several horse stables. They are landlords that take care of the horses, charging the owner. However, this alternative seems to give fewer advantages because they need to invest a great amount of resources on food, watering and veterinary care, which reduce their profits. According to some horse caretakers if grass and water were available they would be able to reduce costs and they would even have the chance to produce livestock again that would be more profitable.

Finally, in San Pedro, the growth in the establishment of industrial and maquiladora centres that have expanded since the last decade as result of the North American Free Trade Agreement, provides jobs to some inhabitants of the community, but participants complain that salaries are low. However, they recognise that some members of the community prefer them because people receive benefits such as social security or a Christmas bonus. The proximity of cities is fundamental for some people to find work options, while abandoned lands does not have productivity in recent times.

In Los Pargos since most of the families are involved in the brick production, the problem is having more heat because producers need to start working earlier otherwise it is arduous. A participant mentioned that they start to work at three or four in the morning to avoid the heat. Also participants explained how working in City of Aguascalientes has become an alternative for some people in the community. Particularly, the Nissan Company hires a lot of people from the surrounding areas. They reflect that having a job in Aguascalientes has advantages because it is less hard work than brick production, since typically employees are not exposed to heat and diseases. However, they also complain that these are low paid jobs. Participants mentioned that Los Pargos receives tourists from City of Aguascalientes, but most of women do not perceive any benefit of this, on the contrary they complain because tourists bring garbage.

#### 3.2.1. Mapping of the communities

During the workshop, participants of the first group of each community were asked to draw a map of the ejido. In the case of Los Pargos, the map indicates the two main access roads to the community, and most of the households dispersed into the banks of the dam, these are distinguished by TV antennas in the upper part (Fig. 4). The representation of the dam in the central area is shown with the presence of fish and ducks. The participants marked three brick kilns along the path of the second entrance road and another three along the stream, adjacent to the houses. The drawing highlights the presence of nopal plants towards the north, next to the main entrance road, and in front of them there is a school, a grocery shop and a church, near they draw a garbage container. It presents milpas (agriculture areas) and places with sheep, cows, pigs as well as a horse stall. In the part that continues the path of the second road that goes to the south (left direction in the representation) marks the location of an area with medicinal plants, next they indicate the presence of rabbits. The delimitation of the territory is marked surrounded by mountain, with pastures and trees. The participants highlighted an area with flood risk located between the two access roads to the community and in the end of the secondary road there is a water well and an area marked as a tolerance zone, although many people from Aguascalientes City do not know the community, they do know where the tolerance zone is.

This map representation of Los Pargos shows the importance and distribution of natural resources, such as the dam, fish, nopal plants, medicinal plants and other resources such as trees and grass. It shows the poor infrastructure of the community with only one school and a grocery shop, and with the presence of one garbage container. The spread of brick kilns along the territory is evident. Although they indicated an area with risk of flooding, during the workshops they also confirmed that flood events are scarce.

<sup>1</sup> This mine contaminated the Sonora River and it was sanctioned. However, the public perception is that the amount of the fine was not enough to repair the environmental damage caused in the region.



**Fig. 4.** Map of Los Parga drawn by the participants.

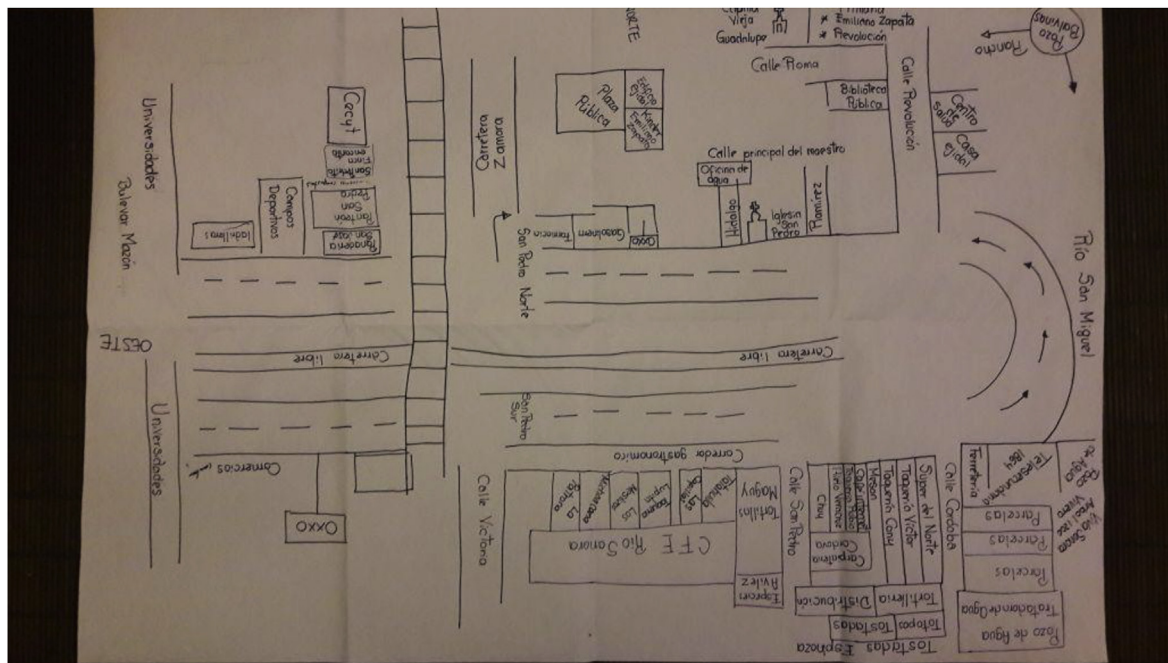
The map drawn by women participants in San Pedro el Saucito shows that the community is located on the Zamora-Victoria highway (Fig. 5). This map, unlike the previous one, shows elements that refer to

a more geometric trace that can be identified as urban, where the gastronomic corridor is located on the edge of the highway. This gastronomic corridor shows multiple locations, that refer sometimes to the name of the place and others to the type of food they sell. There are commercial establishments located along the road, and others scattered in internal streets. There are 3 schools, a kindergarten, a secondary school and a technical school, located in different places. It is indicated that there is a wastewater treatment plant and the presence of a parastatal company of the electricity distribution (CFE). Participants also highlighted the presence of private universities, towards the direction marked as west, it shows a deliberate location towards the limits of the community since the young people of the community do not study there. However, they mark an area of sports fields, close to few brick kilns. It also shows a public square, a gas station and a water utility office, as well as a church, a public library, a health centre and the ejido office. The San Miguel river is marked as an arch with four arrows following a path of the axis, it should be noted that the river has remained dry for several years. On this map, the group of participants did not indicate any particular risk area.

The map representation of San Pedro el Saucito shows the presence of a richer infrastructure. The importance of the highway with the gastronomic corridor is evident, and most of the infrastructure is located in the highway area. Some commercial and public infrastructure serves the local community, but other that belong to external actors.

The above information shows that the impact on their subsistence means differ and the adaptation strategies respond to the challenge faced in each community. Whereas in Los Pargos the effects of increased heat and reduction in precipitation seem to be moderated, it had not reorganized dramatically the economic activities. In San Pedro the acute effects had changed agriculture and livestock production, and transformed into a rapid change in the economic dynamic of the area, leading people to find other sources of income. In both areas, the option of finding jobs in the city has also improved or compensated their economic alternatives.

Some adaptation strategies are revealed in these sentences: “The government help us to make a tourist food corridor and the community itself makes the food and sells it. [During the food fair] we expected 5,000 people for this year but there were 12,000 people, there was an economic spree. The gastronomic time is in April”



**Fig. 5.** Map of San Pedro el Saucito drawn by the participants.

(Woman, San Pedro).

"San Pedro is very popular because of the "tortilla sobaqueras", large ones, corn tamal, beef tamal with chilli and roast beef. There is event of a food contest." (Woman, San Pedro).

"If horse care people had water as before they would have alfalfa produced here and they would not have to buy food that now are buying from outside, these people buy food all year around" (woman, San Pedro).

"When the engineers constructed the highway the return did not make it close, then people have to drive two kilometres to cross to the other side of the town" (woman, San Pedro)

"Large producers constructed wells, I had my plot at about 500 m of a well, but when they constructed their well after 15 days I had no water anymore (man, San Pedro).

"Before water was extracted from 10 m, but the government made deep wells at 800 feet (man, San Pedro).

"Now the water goes to Hermosillo. The water of Hermosillo was taken from this community" (man, San Pedro).

"There is a field of one thousand hectares of grapes, how much water do they extract?" (man, San Pedro).

"Before, there were not so many options for working outside the brick factory" (woman, Los Pargos).

"We work with my dad making the bricks, because in this season the sales increase (May), but working the brick must be done before the heat begins" (woman, Los Pargos).

"Trash is brought by outside visitors. The containers next to the Dam are filling up, and sometimes overflows and garbage flies" (woman, Los Pargos).

### 3.3. Adaptive capacity of the community

Some community rules, procedures, norms, practices and institutions, between others influence vulnerability and collective adaptive capacity to find inclusive and consensus seeking. San Pedro seems to have functional governance structures that allow them to make joint decisions. One participant provided comments about the consensus-based process driven by community leaders to ensure support decisions, by monthly meetings and procedures to collect financial contributions and give permissions for commerce, among others.

On the contrary, participants in Los Pargos commented that their decision-making process was not inclusive, with most indicating a lack communication and consensus on the common problems. Participants explained that they hardly meet to discuss any issue, but stressed the importance of developing an inclusive process in generating actions to improve problematic areas. Few participants stated that leaders decided on behalf of the community influenced by local politicians. There seem to be few community ties between the neighbourhood in its decision-making process in the face of environmental degradation and food security.

Although few participants in Los Pargos expressed that collaboration with NGOs and other people interested in the area is valuable, most perceived this as not having a clear impact on their conditions. One person mentioned that she works for promotion programs in the government, but her work is difficult in the community because "people do not cooperate, they do not attend meetings". This type of comment was shared by other participants, indicating that there are difficulties to coordinate actions among the members of the community. In fact, a participant felt that a leader is needed to promote changes. Others preferred that authorities and other stakeholders help them to improve the situation, because basic services such as transport and health are

scarce.

"There is the ejido commission, where decisions are taken" (man, San Pedro).

"We need someone who represents us, with the ability to speak" (woman, Los Pargos).

#### 3.3.1. Governance: capacities and responsibilities of institutional actors and organizations

In San Pedro diverse participants, mainly men in the workshop, expressed that official programs do not fit their needs, most perceived that public resources are directed to large producers. They indicated that for some official programs, the federal government provides partial subsidies, but they cannot afford to give the matching funds.

Both communities mentioned insufficient health services. In the case of San Pedro, the local clinic has insufficient equipment, personnel and infrastructure (for instance, they establish the need to buy an ambulance). The clinic serves as 10 surrounding communities. However, the difficulties seem to be greater in Los Pargos due to the absence of permanent medical services. People here must walk to the neighbouring community of Los Arellanos to obtain medical services and wait for an appointment, with the disadvantage that the doctor gives appointments to the residents of Los Arellano and those who travel from Los Pargos should line up and wait for available slots. In addition, there is lack of public transport in the community, thus many people walk from 45 min to an hour to the shopping area or to medical services.

Participants envision options to improve their current situation that would be an option if some policy instruments were available to support their efforts. In San Pedro, participants, but particularly men, demanded more information and scientific studies to justify actions and investment, commenting that they need advice and more education. While men recognized the need to address agricultural production decline, they suggested other measures such as drilling deeper wells and the use of drip irrigation systems. They mentioned that there are experiences of improved irrigation techniques, because most of the remaining agricultural producers in the community are using drip irrigation systems. Moreover, participants, but particularly men are aware and willing to invest in drip irrigation systems.

Participants in San Pedro mentioned that people in the community have experience producing cheese and that they might take advantage of access to buffel grass in the open bush. One participant man mentioned that there is technical knowledge to improve the soils through composting and the vermicomposting, and to preserve the products by means of refrigeration system; both experiences would be available to integrate into a demonstration plot. They also recognise that they can develop their new economic activities in the horse care business but they can be more competitive having access to water and grass production to feed horses.

Participants in Los Pargos mentioned the possibility of taking advantage from the visitors from Aguascalientes City to the dam. Few women reflected on the potential benefits from this tourism, with the possibility of selling food or other services. However, the community requires improvement in public transport, public security and health services as a precondition to improve their wellbeing.

All this option suggested by the community members might become potential lines to adjust current official programs or create new ones that support people's capacities.

Here we can observe some participants' concerns about the governance situation in their context:

"People suffer a lot with the transport when they go for the children to the school, also much security is lacking " (woman, Los Pargos).

"The health centre is in Arellanos, it's an hour away. To reach an



appointment you must arrive at 6 am.” (woman, Los Pargos).

“There are government support. For instance, the Procampo Program (subsidy program for agriculture) pay 4800 pesos per year (270 dollars), but the COTA (permission for water extraction) charges 2800 pesos (170 dollars) per year and besides I pay 400 pesos (22 dollars) for environmental sanitation. These expenses plus transportation no longer make profitable the money given by Procampo” (man, San Pedro).

“I also know about experiences with dairy cows under stabulation conditions. However, this is constrained by the possibility of having a community water well”.

“I had the chance to see some lettuces in a pvc tube ... Sometimes I think we need more education on how to do things and have motivation, such as making dams or mountain improvement”

### 3.4. Classification of impacts and local effects

Climate change literature highlights that changes in weather and climate variables impact the most basic socio-ecological structure, particularly temperature and precipitation (IPCC, 2007, 2014; Seneviratne et al., 2012). The IPCC mentions examples of possible impacts of climate change due to changes in extreme weather and climate events, based on projections indicate effects on agriculture, water resource, human health, settlements and society (IPCC, 2007, p. 53). Considering the impacts mentioned by participants in the two peri-urban areas and the categories used by the IPCC, here we simplified the categories of impacts on three areas: households' wellbeing, economic activity, and infrastructure. Tables 4 and 5 compile findings listed throughout the workshops. These tables summarise the effects distinguishing whether a specific impact on temperature and rainfall has an effect on categories of households' wellbeing, economic activity, or infrastructure.

From household's wellbeing perspective, the increase in temperature has impacts on food spoilage, discomfort and reduced possibility of being outdoors and increase in human morbidity. Both communities perceive that the effects of rainfall reduction produce more dust given the lack of pavement that affects mostly household's wellbeing. From an economic perspective, increase in temperature impacts livestock morbidity and mortality and decreases agriculture and livestock production, though in San Pedro the impact is greater. The reduction in rainfall has major impacts to economic activity because this reduces the production and quality of harvested food in both communities, again with different magnitudes. Nevertheless, there are certain variations that reflect the intensity of the impacts, such as abandonment of agricultural and livestock activities, dryness of water wells and propagation of vector borne diseases in San Pedro. Other differences are associated with the specific characteristics of the community such as impacts on

wild food in Los Pargos due to reduction in rainfall that impacts households' wellbeing, while the discomfort produced by heat in brick production impacts the economic activity.

Both communities are impacted by water scarcity as the reduction in rainfall amount has an impact on water wells in San Pedro, and the water level in the dam in Los Pargos. Also abandonment of agriculture and livestock activities impacts the infrastructure that the community had previously developed, particularly in San Pedro with water wells and agriculture and livestock equipment.

### 4. Discussion and conclusions

Our study examined climate change vulnerability with emphasis on people's' perceptions from a community perspective in two peri-urban areas with risk of droughts: Los Pargos (in City of Aguascalientes) and San Pedro (in City of Hermosillo). These perceptions are useful to explore how people are exposed to climate change impacts and in what way this affects their wellbeing. In these cases, the perceptions are related to exposure of their economic activities, but also to the effects on households' wellbeing and local infrastructure and environmental assets such as community water sources or availability of wild food. These effects are consistent with other studies in Mexico that confirm that local communities perceive impacts of climate change. For instance, Sandoval, et al. (2014) studied a community in Yucatán, Mexico, where respondents perceived that climate change negatively affects their crops and health. In Guanajuato, Vélez-Torrez et al. (2016) also found that rural and peri-urban communities perceive more heat and reduction in precipitation.

In this case, San Pedro and Los Pargos livelihoods are directly tied to a semi-arid environments and drought risk, thus people's perceptions show certain similarities, but important differences in vulnerability to climate change. In Los Pargos and San Pedro there is a shared awareness of changes in weather, with impacts on more heat and less rainfall in recent years. However, the vulnerability experienced by both communities differs drastically and is conditioned by the dimensions of exposure to the weather fluctuations. Participants in San Pedro perceive and discuss about acute changes in increasing temperature, reduced rainfall and scarce water availability, denoting a higher exposure. Participants in Los Pargos perceive reasonably moderate changes in temperature with heat and cold extremes, but less rainfall, and without indication of water scarcity.

Perceptions show that the sensitivity or impact on their subsistence means differ. Whereas in San Pedro climate change and the competition for the water resource produced major impacts; in Los Pargos the effects produced more moderate ones. The explanation seems to be that the brick production as the leading economic activity in Los Pargos is not severely impacted by weather changes. On the contrary, this activity tackles the natural resources of the place and contributes in an accelerated way to the pollution of the environment. This situation shows

**Table 4**  
Perceived impacts of climate change in San Pedro, Hermosillo.

Perceived effects	Associated impact	Areas impacted by climate change		
		Household wellbeing	Economic activities	Infrastructure
Increase in temperatures and heat waves	Food spoilage	*	*	
	Discomfort, reduced possibility of being outdoors	*	*	
	Increase in human morbidity	*		
	Increase in vectors (flies & mosquitos), and vector borne disease	*		
	Livestock morbidity and mortality		*	
	Lower agricultural and livestock production		*	
Reduced rainfall	Reduced production and quality of harvested food		*	
	Water wells go dry		*	*
	Water shortages for all sectors	*	*	
	Dust	*		
	Abandonment of agricultural and livestock activities		*	*

**Table 5**  
Perceived impacts of climate change in Los Pargos, Aguascalientes.

Perceived effects	Associated impact	Areas impacted by climate change		
		Household wellbeing	Economic activities	Infrastructure
Increase in temperatures	Food spoilage	*		
	Discomfort, reduced possibility of being outdoors	*		
	Discomfort in brick production		*	
	Increase in human morbidity	*		
	Livestock morbidity and mortality		*	
	Lower agricultural and livestock production		*	
Reduced rainfall	Dam go dry		*	*
	Dust	*		
	Impacts on wild food (nopal, rabbits, medicinal plants)	*		

a loss of activities in the primary sector which might impact urban food security. In fact, several studies of the potential impacts of climate change on agricultural production in Mexico are consistent finding possible reductions in yields for a wide range of crops. The predictions are not optimistic for large wheat and corn producers of Sonora and Sinaloa, nor for the millions of small farmers and their milpa, that is why the threat of climate change to food security and sovereignty is considerable in this semi-arid territory (Conde-Álvarez and López-Blanco, 2016; Monterroso et al., 2015).

This effect on food availability is connected with wild food in Los Pargos, because it refers to the term of agricultural biodiversity recognized as an essential component in the sustainable delivery of a secure food supply. Agricultural biodiversity includes not only the rich variety of species and plant, genetic resources and animals, but also those ways in which producers use biodiversity to harvest and manage crops, land, water, insects (be they beneficial or pests) and other organisms, such as pollinators (FAO, 2007). As other studies indicate climate change puts pressure on the sources of food of vulnerable people (IPCC, 2014).

The adaptive capacity is related to access to government support programs or services. Nevertheless, in San Pedro participants complained about a clear deficiency of institutional programs to reduce vulnerability in the agricultural and livestock sector. As mentioned before, Mexico has a number of policy instruments to promote the conservation and sustainable use of biodiversity and forests, as well as for energy saving actions; however, none of this programs were used in these communities. For instance, in Los Pargos where there is a forest and some animal species are abundant or in San Pedro el Saucito where agriculture and energy problems are evident. Here it is interesting that the Vázquez-León et al. (2003) study that compared two areas sharing the same ecosystem conditions in the Municipality of Alamos, in Sonora, the same state where San Pedro is located and Arizona in the USA. They observed how the local producers in Arizona have adapted to weather variability by using efficient irrigation technologies, crop diversification and market orientation. They found how small-scale rural producers in Mexico ended up not planting, lost their cattle and some had to sell lands. In terms of government support the US government provides incentives to farmers for adoption of water efficient technologies, gives low interest loans and provides crop disaster programs, while crop insurance is required by banks and federal agencies. Vélez-Torrez et al. (2016) found that given the change in temperature, some farmers in peri-urban and rural communities in Guanajuato, Mexico, have also used adaptation strategies such as shifting cultivation, use of native seeds and incorporation of organic matter to the soil, but they state that there is not direct support of government authorities to design climate change adaptation strategies in these peri-urban and rural contexts based on climate change policies. This confirms the importance of adaptation strategies in local communities and the dynamics of spontaneous adaptation when the disaster struck. Under this perspective people implemented direct actions to confront changes in temperature, actions that have not been imposed by models,

institutions or external actors, but have emerged empirically as a result of their own knowledge, experience and necessity (Pinilla-Herrera et al., 2012).

In the case of peri-urban areas, the adaptive capacity is conditioned by the proximity to urban areas, because both communities receive benefits through enlarged economic activities and certain access to public services. In both communities a proportion of people find jobs in the city or industry around the urban area. Also important is the capacity of both communities to receive tourism from the city. In fact, San Pedro has developed tourism-based activities associated with food commercial establishments and horse care activities that have reduced their economic dependence of the traditional agricultural sector. However, there are still people dependent on the agricultural and livestock sector, including those in the horse care activities because scarcity of water and pasture reduces their profits. In comparison, Los Pargos receives tourism because the area is rich in natural assets with the presence of a dam and forest, but no economic benefit is received by the community. Nevertheless, this condition might become an alternative to diversify their economic activities, and obtain benefits of its location in a rich ecological area and its closeness to the city.

Despite climate change impacts seem less severe in Los Pargos with their focus on the production of bricks, the marginality is greater. The distance to access health facilities, the lack of public transport, and the lack of communication and social actions and networks are factors that impact their wellbeing under a weather-changing environment. In comparison, San Pedro has certain services such as modest health facilities; access to private transport and strong societal ties that allow them to empowered and establish joint solutions to their problems.

Adaptation strategies to reduce vulnerability to impacts of climate change in these peri-urban communities would require the analysis of options that at the individual and community level would make them more climate resilient. As the IPCC indicate there are different alternatives depending on the specific conditions. In San Pedro el Saucito, the economic activities would increase their resilience by installing and/or increasing the area with drip irrigation or other water saving irrigation systems, which was an option mentioned during the workshops. However, given the scarcity of water resources for agricultural use, building greenhouses would become a more realistic option in this area to defend plants from heat and evaporation. The experience of Arizona in the United States that use efficient irrigation technologies, crop diversification and market orientation seems to be useful, but given that in San Pedro there are small-scale rural producers their restricted capacity needs to be supported with external resources.

Regarding household wellbeing, in San Pedro el Saucito, options such as installation of solar cells to generate energy might be an alternative to reduce air conditioning costs, moreover considering that in Mexico there is access to the above mentioned soft credits offered by the Saving Energy Fund (FIDE), thus the community could be informed to follow the procedures in order to access this subsidy scheme. Actions to make minor adjustments to the houses in order to temperate the heat, using for instance thick curtains or changes in certain materials also

would be an alternative. Reducing, reusing and collecting waste might decrease the risk of spread of mosquito and improve the environment in public spaces. An important strategy is the improvement and use of green infrastructure, through planting trees and other vegetation in order to have shadow, regulate the local temperature, control dust and connect the ecosystem with the rural areas. These are some options that might reduce exposure of San Pedro el Saucito to the increasing patterns of climate change oriented to drought environments.

In the case of Los Pargos the options could be more oriented to make adaptations at the household level to use grey water toward dripping the green spaces, in particular the nopal and maguey plants that are direct sources of food. Actions to maintain and improve the green infrastructure in public and private spaces would also maintain the rainwater infiltration service while reducing dust and alleviating the heat discomfort in open spaces. Using materials for the brick ovens that diminish the need to exploitation surrounding natural materials such as wood is also important. Any cheap filter technology that reduces the polluting emissions of ovens would be also valuable. Finally, the option of reducing, reusing and collecting waste might also decrease the risk of spread of mosquito and improve the environment in public spaces, particularly near the dam area that receives tourism. Here the diversification of economic activities toward ecotourism activities would generate additional economic resources for the community.

The willingness to try new strategies to adapt to weather variability seems to have a greater chance to be tested in San Pedro due to their vulnerability and greater organization. The incentive seems to be important among men involved in agriculture and livestock production including horse care to adopt more sustainable practices, such as finding options to increase water sources, use drip irrigation systems or to adopt soil conservation practices. We also expect that the level of participation in San Pedro facilitate implementation of any recommendation to adapt. The commitment of the local leaders combined with group dynamics of organised women might generate a sufficient level of consensus over the alternatives that could be taken to reduce their vulnerability. In Los Pargos, the community seems to be more impacted by the reduction in wild food, therefore the intervention to maintain wild food assets might be important. Also new source of energy for brick kilns might generate enough interest to bring them together for possible shared projects. However, more information might be needed to understand the impacts of climate change in this community from a male perspective.

Adaptation should be viewed as a process and not as a final state, which allows taking into account socio-economic dynamics and geopolitical aspects of societies. Learning process involves monitoring and review of policies, plans and actions. There is a need to transcend traditional schemes, planning to integrate interdisciplinary knowledge and multidimensional aspects are required to incorporate initiatives and actions from bottom to top. “Community-based adaptation” should be guided by communities considering their priorities, needs, knowledge and ability to empower people to plan and cope with the impacts of climate change (SEMARNAT, 2012: 34). On the basis of the perception and existing practices, the dimension of current practices and new adaptive actions of which the communities have no experience can be recommended and assessed by the community and supplemented by external stakeholders. However, from the policy perspective we consider that adaptation strategies require more deliberate integration of ecological and social criteria based on communities’ specific conditions.

Workshops appear to have been effective in establishing understanding of the potential impacts of climate change rather than having at risk areas imposed by a top-down process. People’s ability to easily identify how changes in temperature and rainfall patterns have effects on multiple areas, including specific aspects of households’ wellbeing, economic activities and infrastructure suggests that weather changes and water scarcity are becoming more evident. In fact, Berkes et al. (2000), affirm that the knowledge, subjectivities, perceptions and experience of rural and indigenous communities configure another type of

knowledge that has great validity and, in many cases, has been complementary or analogous to scientific knowledge.

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## References

- Alfie, M., 2017. Análisis de la vulnerabilidad y resiliencia al cambio climático en sistemas socio-ecológicos periurbanos”, Project Report. Mexico City, July 14, 2017.
- Altieri, M.A., Toledo, V.M., 2005. Natural resource management among small-scale farmers in semi-arid lands: building on traditional knowledge and agroecology. *Ann. Arid Zone* 44 (3/4), 365.
- Arias, P., 2005. Nueva Ruralidad: antropólogos y geógrafos frente al campo hoy” en: Ávila, H. (coord.) *Lo urbano-rural, ¿nuevas expresiones territoriales?* CRIM-UNAM, Cuernavaca, pp. 123–159.
- Ávila, S.H., 2001. Ideas y planteamientos teóricos sobre los territorios periurbanos. *Las relaciones campo-ciudad en algunos países de Europa y América*, Investigaciones Geográficas, vol. 45. Boletín del Instituto de Geografía, México, pp. 108–127 IG-UNAM.
- Berkes, F., Colding, J., Folke, C., 2000. Rediscovery of traditional ecological knowledge as adaptive management. *Ecol. Appl.* 10, 1251–1262.
- Braun, V., Clarke, V., 2012. Thematic analysis. In: Cooper, H., Camic, P.M., Long, D.L., Panter, A.T., Rindskopf, D., Sher, K.J. (Eds.), *APA Handbook of Research Methods in Psychology, Vol. 2: Research Designs: Quantitative, Qualitative, Neuropsychological, and Biological*. American Psychological Association, Washington, DC, pp. 57–71.
- CENAPRED, 2014. *Seguías. Serie Fascículos*. Centro Nacional de Prevención de Desastres. Secretaría de Gobernación.
- Chaudhary, P., Bawa, K.S., 2011. Local perceptions of climate change validated by scientific evidence in the Himalayas. *Biol. Lett.* 7 (5), 767–770. <https://doi.org/10.1098/rsbl.2011.0269>.
- CONANP-GIZ. Comisión Nacional de Áreas Naturales Protegidas (CONANP), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, 2014. *Herramienta para analizar vulnerabilidad social a impactos de Cambio Climático en áreas naturales protegidas de México*. CONANP, GIZ, México.
- Conde-Álvarez, A.C., López-Blanco, J., 2016. Variabilidad y Cambio Climático. Impactos, Vulnerabilidad y Adaptación al Cambio Climático en América Latina y el Caribe. *Propuestas para Métodos de Evaluación*. SEMARNAT, INECC, KOIKA, AMEXID, México.
- De Alba, M., 2012. Representaciones sociales y el estudio del territorio: aportaciones desde el campo de la Psicología Social. *LAST Laboratorio de Análisis Socioterritorial*. Universidad Autónoma Metropolitana, Unidad Cuajimalpa. Distrito Federal.
- Eakin, H., Benessaiah, K., Barrera, J., Cruz-Bello, G.M., Morales, H., 2012. Livelihoods and landscapes at the threshold of change: disaster and resilience in a Chiapas Coffee community. *Reg. Environ. Change* 12, 475–488.
- Ebi, K.L., Semenza, J.C., 2008. Community-based adaptation to the health impacts of climate change. *Am. J. Prev. Med.* 35 (5), 501–507.
- FAO, 2007. *La importancia de la biodiversidad agrícola para la seguridad alimentaria, la nutrición y la calidad de vida en América Central*. <ftp://ftp.fao.org/docrep/fao/010/k0094s/k0094s02.pdf>.
- Galindo, Carlos, Delgado, Javier, 2006. Los espacios emergentes de la dinámica rural-urbana. *Problemas del Desarrollo. Revista Latinoamericana del Desarrollo*, vol. 37. pp. 147.
- Gobierno del Estado de Sonora (Government of Sonora State), 2018. *Plan Estatal de Acción ante el Cambio Climático del Estado de Sonora*.
- González, S., Larralde, A., 2013. Conceptualización y medición de lo rural. *Una propuesta para clasificar el espacio rural en México*. La situación demográfica en México 2013.
- Herrera-Pantoja, M., Hiscock, K.M., 2015. Projected impacts of climate change on water availability indicators in a semi-arid region of central Mexico. *Environ. Sci. Pol.* 54, 81–89. <https://doi.org/10.5751/ES-05063-170330>.
- Heyd, T., 2010. Climate change, individual responsibilities and cultural frameworks. *Hum. Ecol. Rev.* 17 (2), 86–95.
- IEA- International Energy Agency, 2016. *World Energy Outlook Special Report on Mexico*. OECD/IEA, Paris.
- Instituto Nacional de Estadística y Geografía. (INEGI), 2017. *Directorio Estadístico Nacional de Unidades Económicas (Aguascalientes)*. En línea [metadato]. Recuperado de: <http://www.beta.inegi.org.mx/app/descarga/?ti=6>.
- Instituto Nacional de Estadística y Geografía, 2016. *Conjunto de datos vectoriales de uso de suelo y vegetación. Escala 1:250,000*. En línea [metadato]. Recuperado de: <http://www.beta.inegi.org.mx/temas/mapas/usuariosuelo/>.



- Instituto Nacional de Estadística y Geografía (INEGI), 2016. Marco Censal Agropecuario. INEGI, Mexico. Retrieved from <http://www.inegi.org.mx/est/contenidos/proyectos/accesomicrodatos/amca/default.aspx>.
- Instituto Nacional de Estadística y Geografía (INEGI) y Gobierno de Aguascalientes, 2015a. Anuario estadístico y geográfico de Aguascalientes. Available at: [http://www.datatur.sectur.gob.mx/ITxEF\\_Docs/AGS\\_ANUARIO\\_PDF15.pdf](http://www.datatur.sectur.gob.mx/ITxEF_Docs/AGS_ANUARIO_PDF15.pdf) (17/10/2017).
- Instituto Nacional de Estadística y Geografía (INEGI) y Gobierno de Sonora, 2015b. Anuario estadístico y geográfico de Sonora. Available at: [http://www.datatur.sectur.gob.mx/ITxEF\\_Docs/SON\\_ANUARIO\\_PDF15.pdf](http://www.datatur.sectur.gob.mx/ITxEF_Docs/SON_ANUARIO_PDF15.pdf) (17/10/2017).
- Instituto Nacional de Estadística Geografía e Informática (INEGI), 2010. Censo de Población y vivienda. Consultado el 12/03/2017. [http://www.inegi.org.mx/sistemas/consulta\\_resultados/ageb\\_urb2010.aspx?c=28111&s=est](http://www.inegi.org.mx/sistemas/consulta_resultados/ageb_urb2010.aspx?c=28111&s=est).
- IPCC, 2007. Climate Change 2007: Synthesis Report Summary for Policymakers. Assessment of Working Groups I, II and III to the Third Assessment Report of the International Panel on Climate Change. Cambridge University Press, Cambridge.
- IPCC, 2014. Climate Change 2014. Synthesis Report, Summary for Policy-makers. Intergovernmental Panel on Climate Change.
- IPCC, 2012. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change In: Field, C.B., Barros, V., Stocker, T.F., Qin, D., Dokken, D.J., Ebi, K.L., Mastrandrea, M.D., Mach, K.J., Plattner, G.-K., Allen, S.K., Tignor, M., Midgley, P.M. (Eds.), Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. Cambridge University Press, Cambridge, UK, and New York, NY, USA 582 pp.
- Kernan, B., Ceballos, G., Solberg, S., Medellín, R., Griswold, D., Seager, M., Equihua, C., García, C., Pisanty, I., 2013. Mexico tropical forest and biodiversity assessment. US foreign assistance act, section 118/119 report. April, 2013. Liverman, D. M. (1990). Drought impacts in Mexico: climate, agriculture, technology, and land tenure in Sonora and Puebla. *Ann. Assoc. Am. Geogr.* 80 (1), 49–72.
- Krueger, R.A., Casey, M.A., 2015. Focus Groups: a Practical Guide for Applied Research. Sage Publications, Thousand Oaks, Calif.
- McPhearson, T., Andersson, E., Elmqvist, T., Frantzeskaki, N., 2015. Resilience of and through urban ecosystem services. *Ecosystem Services* 12, 152–156.
- Midgley, S., Dejene, A., Mattick, A., 2012. Adaptation to Climate Change in Semi-arid Environments. Experience and Lessons from Mozambique. Environment and Natural Resources Management Series. FAO.
- Monterroso, R.A., et al., 2015. Sistema de Producción de Alimentos y seguridad alimentaria. In: En Gay, C., Cos, A., y Peña, T. (Eds.), Reporte Mexicano de Cambio Climático Grupo II Impactos, Vulnerabilidad y Adaptación. Universidad Autónoma de México.
- Morton, J.F., Solecki, W., Dasgupta, P., Dodman, D., Rivera-Ferre, M.G., 2014. Cross-chapter box on urban–rural interactions—context for climate change vulnerability, impacts, and adaptation. In: B. C., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L. (Eds.), Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 153–155.
- OECD, 2013. Environmental Performance Reviews: Mexico 2013. Environment Policy Committee Working Party on Environmental Performance. OECD.
- Pinilla Herrera, M.C., Sánchez, J., Rueda, A., Pinzón, C., 2012. Variabilidad climática y cambio climático: percepciones y procesos de adaptación espontánea entre campesinos del centro de Santander, Colombia. *Rev. Javer.* 16 (no.31) Colombia. [http://](http://revistas.javeriana.edu.co/index.php/ambienteydesarrollo/article/view/4330)
- revistas.javeriana.edu.co/index.php/ambienteydesarrollo/article/view/4330.
- Sandoval, C., Soares, D., Munguía, M.T., 2014. Vulnerabilidad social y percepciones asociadas al cambio climático: Una aproximación desde la localidad de Ixil, Yucatán. *Sociedad y Ambiente*, año 2, vol. 1, núm. 5, julio-octubre, México.
- SEMARNAT, 2012. Adaptación al Cambio Climático en México: Visión, elementos y Criterios para la Toma de Decisiones. INECC, SEMARNAT, México. <http://www.inecc.gob.mx/descargas/dgipea/ine-ecc-pc-01-2012.pdf>.
- SEMARNAT, 2014–2018. Versión de Difusión del Programa Especial de Cambio Climático. (PECC 2014–2018). Gobierno de la República, Mexico. [https://www.gob.mx/cms/uploads/attachment/file/42488/Programa\\_especial\\_de\\_cambio\\_climatico\\_2014-2018\\_vdifusion.pdf](https://www.gob.mx/cms/uploads/attachment/file/42488/Programa_especial_de_cambio_climatico_2014-2018_vdifusion.pdf).
- Seneviratne, S.I., Nicholls, N., Easterling, D., Goodess, C.M., Kanae, S., Kossin, J., Luo, Y., Marengo, J., McInnes, K., Rahimi, M., Reichstein, M., Sorteberg, A., Vera, C., Zhang, X., 2012. Changes in climate extremes and their impacts on the natural physical environment. In: Managing the risks of extreme events and disasters to advance climate change adaptation. In: B. C., Barros, V., Stocker, T.F., Qin, D., Dokken, D.J., Ebi, K.L., Mastrandrea, M.D., Mach, K.J., Plattner, G.-K., Allen, S.K., Tignor, M., Midgley, P.M. (Eds.), A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 109–230.
- Swim, J., Clayton, S., Doherty, T., Gifford, R., Howard, G., Reser, J., et al., 2009. Psychology and global climate change: Addressing a multi-faceted phenomenon and set of challenges. American Psychological Association, Washington A report by the American Psychological Association's task force on the interface between psychology and global climate change.
- Taylor, A., Dessai, S., Bruine de Bruin, W., 2017. Public priorities and expectations of climate change impacts in the United Kingdom. *J. Risk Res.* 1–11.
- TEEB, 2010. The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: a Synthesis of the Approach, Conclusions and Recommendations of TEEB.
- Tesch, R., 1990. Qualitative Research: Analysis Types and Software Tools. Falmer Press, New York.
- UNDP, 2008. Assessing the Vulnerability of Local Communities to Disasters: an Interactive Guide and Methodology.
- Valdez, R., Guzmán-Aranda, J.C., Abarca, F.J., Tarango-Arámbula, L.A., Sánchez, F.C., 2006. Wildlife conservation and management in Mexico. *Wildl. Soc. Bull.* 34 (2), 270–282.
- Van Aalst, M.K., Cannon, T., Burton, I., 2008. Community level adaptation to climate change: the potential role of participatory community risk assessment. *Global Environ. Change* 18 (1), 165–179.
- Vander Molen, K., 2011. Percepciones de cambio climático y estrategias de adaptación en las comunidades agrícolas de Cotacachi. *Ecuad. Debate* 82, 145–158.
- Vásquez-León, M., West, C.T., Finan, T.J., 2003. A comparative assessment of climate vulnerability: agriculture and ranching on both sides of the US–Mexico border. *Global Environ. Change* 13 (3), 159–173.
- Vélez-Torrez, A., Santos-Ocampo, A., De la Tejera-Hernández, B.G., Monterroso-Rivas, A.I., 2016. Percepción del cambio climático de los agricultores periurbanos y rurales del municipio de León, Guanajuato *Revista de Geografía Agrícola* núm. 57. Universidad Autónoma Chapingo Texcoco, México, pp. 7–18 julio-diciembre, 2016.
- Wheeler, S., Zuo, A., Bjornlund, H., 2013. Farmers' climate change beliefs and adaptation strategies for a water scarce future in Australia. *Global Environ. Change* 23 (2), 537–547.